Hydromodification Category Links:

Channelization and Channel Modification

➔ Physical and Chemical Characteristics of Surface Waters
➔ Instream and Riparian Habitat Restoration

Dams

➔ Erosion and Sediment Control
➔ Chemical and Pollutant Control
➔ Protection of Surface Water Quality and Instream and Riparian Habitat

Streambank and Shoreline Erosion

➔ Eroding Streambanks and Shorelines

Education/Outreach

➔ Educational Programs

2.5 Hydromodification

2.5.1 Introduction

2.5.1.1 Background

The State Water Resources Control Board (SWRCB), California Coastal Commission, and other State agencies have identified seven management measures to address nonpoint sources of pollution from hydromodification. Hydromodification is the alteration of stream and river channels, installation of dams and water impoundments, and streambank and shoreline erosion. The management measures consist of a suite of plans, practices, technologies, operating methods, or other alternatives that may be used in combination to control nonpoint source (NPS) pollution. Associated with each management measure are management practices that are designed to reduce the quantities of pollutants entering receiving waters. The fact sheet prepared for each management measure informs readers of the programs, resources, and case studies specific to California and the management measure.

The seven hydromodification management measures are separated into four categories: (1) channelization and channel modification; (2) dams, (3) streambank and shoreline erosion, and (4) education and outreach. Channelization and channel modification activities straighten, enlarge, deepen, or relocate the natural channel of rivers and streams. Channelization and channel modification activities diminish the quality of aquatic habitats and streamside habitats. It can alter the instream pattern of water temperature and sediment type, as well as the rate of sediment erosion, transport, and deposition. Hardening the banks of streams and rivers with shoreline stabilization protection or armor can accelerate the movement of surface water and pollutants from upstream, causing decreased water quality.

Dams can adversely impact the hydrology and quality of surface waters and riparian habitat in the rivers and streams where they are located. For the purposes of these management measures, dams are defined as constructed impoundments that are either (1) 25 feet or more in height and greater than 15 acre-feet in capacity, or (2) 6 feet or more in height and greater than 50 acre-feet in capacity. Impacts on surface waters and riparian habitats can result from the siting, construction, and operation of dams. Dams can reduce downstream flows affecting water quality and habitat. Construction of the dam can remove vegetation, cause increased sedimentation and turbidity. Shoreline and streambank erosion can occur after installation of a dam, which results in increased sediment load in the water body, affecting aquatic habitats.

The erosion of streambanks and shorelines is a natural process that can be beneficial and detrimental. Some erosion is necessary to provide sediment for beaches in estuaries and coastal bays, to provide point bars and channel deposits in rivers, and for substrate in tidal flats in wetlands. Excessively high erosion can cause sediment to smother aquatic vegetation, cover shellfish beds and tidal flats, fill in riffle pools, and contribute to increased turbidity and nutrients.

Plan for California's Nonpoint Source Pollution Control Program Volume II: California Management Measures for Polluted Runoff (SWRCB and CCC, 2000) defines the even hydromodification management measures as follows:

- **Channelization and Channel Modification.** California's management measures for channelization and channel modification promote the evaluation of channelization and channel modification projects. Channels should be evaluated as a part of the watershed planning and design processes, including watershed changes from new development in urban areas, agricultural drainage, or forest clearing. The purpose of the evaluation is to determine whether resulting NPS changes to surface water quality (Management Measure 5.1A. Physical and Chemical Characteristics of Surface Waters) or instream and riparian habitat (Management Measure 5.1B. Instream and Riparian Habitat Restoration) can be expected and whether these changes will be good or bad. Existing channelization and channel modification projects can be evaluated to determine the NPS impacts and benefits associated with the projects. Modifications to existing projects, including operation and maintenance or management, can also be evaluated to determine the possibility of improving some or all of the effects without changing the existing benefits or creating additional problems. In both new and existing channelization and channel modification projects, evaluation of benefits and/or problems should be site-specific.
- **Dams.** The second category of management measures addresses NPS pollution associated with dams. Dams are defined as constructed impoundments that are either (1) 25 feet or more in height and greater than 15 acre-feet in capacity, or (2) 6 feet or more in height and greater than 50 acre-feet in capacity. Management Measure 5.2A. Erosion and Sediment Control and Management Measure 5.2B. Chemical and Pollutant Control address two problems associated with dam construction: (1) increases in sediment delivery downstream resulting from construction and operation activities, and (2) spillage of chemicals and other pollutants to the waterway during construction and operation. Management Measure 5.2C. Protection of Surface Water Quality and Instream and Riparian Habitat addresses the impacts of reservoir releases on the quality of surface waters and instream and riparian habitat downstream.
- **Streambank and Shoreline Erosion.** Management Measure 5.3A. Eroding Streambanks and Shorelines addresses the stabilization of eroding streambanks and shorelines in areas where streambank and shoreline erosion creates a polluted runoff problem. Bioengineering methods such as marsh creation and vegetative bank stabilization are preferred. Streambank and shoreline features that have the potential to reduce polluted runoff should be protected from impacts, including erosion and sedimentation resulting from uses of uplands or adjacent surface waters. This management measure does not imply that all shoreline and streambank erosion must be controlled; the measure applies to eroding shorelines and streambanks that constitute a NPS problem in surface waters.
- **Education/Outreach.** Management Measure 5.4A. Educational Programs focuses on the development and implementation of pollution prevention and education programs for agency staffs and the public, as well as the promotion of assistance tools that emphasize restoration and low impact development. Education, technical assistance, incentives, and other means can be used to promote projects that reduce NPS pollutants, which retain or reestablish natural hydrologic functions (e.g., channel restoration projects and low impact development projects), and which prevent and remedy adverse effects of hydromodification activities.

2.5.2 General Resources

There are several federal and State agencies and programs that can provide general information to address NPS pollution from hydromodification from entering receiving waters. The agencies and programs listed below can provide assistance and information for all seven management measures. Resources specific to each of the seven hydromodification management measures can be found on the corresponding fact sheet.

- **California Coastal Commission** (http://www.coastal.ca.gov/): The California Coastal Commission's primary mission is to plan for and regulate land and water uses in the coastal zone consistent with the policies of the Coastal Act. Programs include permitting, planning, enforcement, and resource protection.
- **The Coastal NPS Pollution Control Program** (http://www.coastal.ca.gov/nps/npsndx.html): This program addresses nonpoint pollution problems in coastal waters. In its program, a state or territory describes how it will implement NPS pollution controls. This program is administered jointly with the U.S. Environmental Protection Agency (USEPA) and the National Oceanic and Atmospheric Administration (NOAA).
- **U.S. Army Corps of Engineers (USACE)** (http://www.usace.army.mil/) USACE's mission is to provide quality, responsive engineering services to the nation including: planning, designing, building, and operating water resources and other civil works projects; designing and managing the construction of military facilities for the Army and Air Force; and providing design and construction management support for other defense and federal agencies.
- **U.S. Fish and Wildlife Service South Pacific Division** (http://www.fws.gov/): The South Pacific Division's mission is to conserve, protect, and enhance the nation's fish and wildlife and their habitats for the continuing benefit of people.
- **Clean Water Act Section 401 Certification Program** (http://www.swrcb.ca.gov/cwa401/index.html): Through the Clean Water Act (CWA) section 401 certification program, Regional Water Quality Control Boards (RWQCBs) review projects that require a federal permit under CWA section 404 or that involve dredge or fill activities that may result in a discharge to waters of the United States. This is to ensure that the State's interests are protected on any federally permitted activity occurring in or adjacent to waters of the State. Detailed information about CWA section 401 in California, including a description of the program, resources, legal background information, proposed projects, and links, are described on the SWRCB Web site.

2.5.2.1 References

SWRCB and CCC. 2000. *Plan for California's Nonpoint Source Pollution Control Program Volume II: California Management Measures for Polluted Runoff*. State Water Resources Control Board and the California Coastal Commission, Sacramento, CA.

Fact Sheet Links:
- Programs
- Management Practices
- Information Resources
- Case Studies
- References

2.5.3 Management Measure 5.1A Channelization and Channel Modification Physical and Chemical Characteristics of Surface Waters

Management Measure

1. Evaluate the potential effects of proposed channelization and channel modification on the physical and chemical characteristics of surface waters.

2. Plan and design channelization and channel modification to reduce undesirable impacts.

3. Develop an operation and maintenance program for existing modified channels that includes identification and implementation of opportunities to improve the physical and chemical characteristics of surface waters in those channels.

2.5.3.1 Programs

- California Environmental Resources Evaluation System (CERES) is an information system developed by the California Resources Agency to facilitate access to a variety of electronic data describing California's rich and diverse environments. The goal of CERES is to improve environmental analysis and planning by integrating natural and cultural resource information from multiple contributors and by making it available and useful to a wide variety of users (http://ceres.ca.gov/).
- The CALFED Bay-Delta Program aims to improve the quality and reliability of California's water supplies and revive the San Francisco Bay-Delta ecosystem. Its Web site contains information about water supply, water quality, and ecosystem restoration (http://www.calwater.ca.gov/).
- The California Department of Fish and Game (DFG) has jurisdictional authority over wetland resources associated with rivers, streams, and lakes under California Fish and Game Code sections 1600 to 1607 (City of Palo Alto, 2001). The DFG has the authority to regulate work that will substantially divert, obstruct, or change the natural flow of a river, stream, or lake; substantially change the bed, channel, or bank of a river, stream, or lake; or use material from a streambed. Typical activities regulated by DFG under sections 1600–1607 authority include rechanneling and diverting streams, stabilizing banks, implementing flood control projects, river and stream crossings, diverting water, damming streams, gravel mining, and logging operations. The DFG encourages completion of a Streambed Alteration Agreement, which is a mutual agreement between the DFG and the project proponent (http://www.dfg.ca.gov/1600/).

2.5.3.2 Management Practices

This management measure applies to any proposed channelization or channel modification project to evaluate potential changes in surface water characteristics, as well as to existing modified channels that can be targeted for opportunities to improve the surface water characteristics necessary to support desired fish and wildlife.

Changes created by channelization and channel modification activities are problematic if they unexpectedly alter environmental parameters to levels outside normal or desired ranges. The physical and chemical characteristics of surface waters that may be influenced by channelization and channel modification include sedimentation, turbidity, salinity, temperature, nutrients, dissolved oxygen, oxygen demand, and contaminants. Changes in natural sediment supplies, reduced freshwater availability, and accelerated delivery of pollutants are examples of the types of changes that can be associated with channelization and channel modification.

In cases where existing channelization or channel modification projects can be changed to enhance instream or streamside characteristics, several practices can be included as a part of regular operation and maintenance programs. New channelization and channel modification projects that cause unavoidable physical or chemical changes in surface waters can also use one or more practices to mitigate the undesirable changes. The practices include the following:

- Structural practices to protect or rehabilitate eroded streambanks are usually implemented in combination to provide stability of the stream system, and they can be grouped into direct and indirect methods. Direct methods include stone riprap revetments, erosion control fabrics and mats, revegetation, burlap sacks, cellular concrete blocks, and bulkheads. Indirect methods include the following: dikes, wire or board fences, gabions, and stone longitudinal dikes.
- Levees are embankments or shaped mounds constructed for flood control or hurricane protection.
- Setback levees and floodwalls are longitudinal structures used to reduce flooding and minimize sedimentation problems associated with fluvial systems. They can be constructed without disturbing the natural channel vegetation, cross section, or bottom slope.
- Check dams are small dams constructed across an influent, intermittent stream, or drainageway to reduce channel erosion by restricting flow velocity. They can serve as emergency or temporary measures in small eroding channels that will be filled or permanently stabilized at a later date, such as in a construction setting.
- Grade control structures are hydraulic barriers (weirs) installed across streams to stabilize the channel, control headcuts and scour holes, and prevent upstream degradation. These structures can be built with a variety of materials, including sheet piling, stone, gabions, or concrete.
- Vegetative cover is used to protect or rehabilitate eroded streambanks. Streambank protection using vegetation is probably the most commonly used practice, particularly in small tributaries. Vegetative cover, also used in combination with other structural practices, is relatively easy to establish and maintain, is visually attractive, and is the only streambank stabilization method that can repair itself when damaged. Appropriate native plant species should be used.
- Structural, vegetative, or bioengineered practices are used to control instream sediment load. Streambank protection and channel stabilization practices, including various types of revetments, grade control structures, and flow restrictors, have been effective in controlling sediment production caused by streambank erosion.
- To minimize erosion and prevent sedimentation impacts on nearby water bodies during construction and operation periods, streamside roadway management needs to combine proper design for site-specific conditions with appropriate maintenance practices.

2.5.3.3 Information Resources

- **North Delta Improvements Project** (http://ndelta.water.ca.gov/index.html): The (NDIP), which is under the Department of Water Resources, presents unique opportunities for synergy in achieving flood control and ecosystem restoration goals.
- **South Delta Improvement Project** (http://sdelta.water.ca.gov/): The purpose of the South Delta Improvements Program (SDIP) is to incrementally maximize diversion capability into Clifton Court Forebay, while providing an adequate water supply for diverters within the South Delta Water Agency, and reducing the effects of State Water Project exports on both aquatic resources and direct losses of fish in the South Delta
- **Washington State Department of Transportation** (http://www.wsdot.wa.gov/eesc/design/roadside/sb.htm): This is a comprehensive Web site, with information on cost, specifications, funding, and case studies.
- **California Forest Stewardship Program.** ***Bioengineering to Control Streambank Erosion*** (http://ceres.ca.gov/foreststeward/html/bioengineering.html): This fact sheet discusses various bioengineering techniques applicable to California streams.
- **WATERSHEDSS: Water, Soil and Hydro-Environmental Decision Support System** (http://www.water.ncsu.edu/watershedss/): The "Educational Component" section of this Web site contains fact sheets that provide information on a variety of techniques for management practices, including soil bioengineering, structural streambank stabilization, and instream practices.
- **Ohio Department of Natural Resources.** ***Stream Management Guide Fact Sheets*** (http://www.dnr.state.oh.us/water/pubs/fs_st/streamfs.htm): This is a compilation of fact sheets on technical guidance for streambank and instream practices, general stream management, and stream processes.

2.5.3.4 Case Studies

Urban Stream Restoration Program. In 2000, a 900-linear-foot reach of degraded stream flowing through a well-used city park was restored by regrading the channel and increasing its sinuosity. The banks were revegetated using native willow and cottonwood cuttings and close to 100 native trees and shrubs from container stock. The East Bay Conservation Corps, under the supervision of the Urban Creeks Council, provided the labor. The California Department of Water Resources, Urban Stream Restoration Program, California Coastal Conservancy, and the San Francisco Foundation funded this project (http://www.urbancreeks.org/Current_Projects.html).

Hunter Creek Salmon and Steelhead Habitat Restoration Project. This project, implemented in 1998 by the California Conservation Corps with guidance from California Department of Fish and Game and U.S. Fish and Wildlife Service, was designed to improve the physical and chemical characteristics of the creek to provide a more suitable habitat. The specific goals of the project were to improve water quality, instream habitat, and the riparian area along the creek. The project had five components:

- *Cleanup*: Approximately 40 car bodies were removed from the streambank.
- *Instream structures*: Boulders, wood structures, and willow posts were placed in the stream and on the streambank to provide habitat complexity and to stabilize streambanks.
- *Fencing to exclude cattle*: The area along both sides of Hunter Creek was fenced to exclude cattle.

- *Planting native vegetation*: Native trees were planted alongside the stream, including willow, alder, Sitka spruce, western red cedar, Douglas fir, coast redwood, big-leaf maple, and black cottonwood.

- *Monitoring*: Photographs are taken at specific locations twice per year to monitor project effectiveness and habitat changes.

More information about this project can be obtained by contacting Scott Bauer of the California Conservation Corps, Klamath Service District, Phone: 707-482-2941; E-mail: sbauer@ccc.ca.gov.

2.5.3.5 References

Federal Interagency Stream Restoration Working Group (FISRWG). 1998. *Stream Corridor Restoration: Principles, Processes, and Practices*. PB98-158348LUW. Federal Interagency Stream Restoration Working Group, Washington, DC.

City of Palo Alto, California. 2001. San Francisquito Creek Bank Stabilization and Revegetation Master Plan: Section 7. (http://www.city.palo-alto.ca.us/sfcreek/) Accessed January 6, 2004.

Fact Sheet Links:

- Programs
- Management Practices
- Information Resources
- Case Studies
- References

2.5.4 Management Measure 5.1B Channelization and Channel Modification Instream and Riparian Habitat Restoration

Management Measure

1. Evaluate the potential effects of proposed channelization and channel modification on instream and riparian habitat.

2. Plan and design channelization and channel modification to reduce undesirable impacts.

3. Develop an operation and maintenance program for existing modified channels that includes identification and implementation of opportunities to restore instream and riparian habitat in those channels.

2.5.4.1 Programs

- CALFED Bay-Delta Program mission is to develop and implement a long-term comprehensive plan that will restore ecological health and improve water management for beneficial uses of the Bay-Delta System (http://calwater.ca.gov/).
- The California Ecological Restoration Projects Inventory (CERPI) is a comprehensive electronic database with details on restoration projects in California. It is searchable on the Internet as part of the Natural Resource Project Inventory (NRPI). The project is the result of collaboration between the California Biodiversity Council and the University of California, Davis, Information Center on the Environment (http://www.ice.ucdavis.edu/nrpi/).
- The Riparian Habitat Joint Venture, started by the California Partners in Flight (CalPIF), is a collaborative effort between 18 federal, state, and private organizations. The focus of the venture is to protect and improve riparian zones bordering streams and lakes (http://www.prbo.org/calpif/htmldocs/rhjv/).
- The Salmon Restoration Project is the result of cooperation between the California Conservation Corps and California Department of Fish and Game. The agencies have been working in partnership with private and public landowners to restore California's salmon and steelhead habitat by adding instream structures. These structures provide shelter for fish, help reduce water temperatures, and add ecological complexity to the stream channel (http://www.ccc.ca.gov/SPECIAL/SRP/srp.htm).

2.5.4.2 Management Practices

The purpose of this management measure is to correct and prevent further detrimental changes to instream and riparian habitat caused by channelization and channel modification projects. The management measure generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. Implementation practices for instream and riparian habitat restoration in planned or existing modified channels are consistent with those management practices for physical and chemical characteristics of channelized or modified surface waters. To prevent future impacts on instream or riparian habitat or to remedy current problems caused by channelization or

channel modification projects, include one or more of the following practices to mitigate the undesirable changes.

- Structural practices to rehabilitate eroded streambanks are usually implemented in combination to provide stability of the stream system, and they can be grouped into direct and indirect methods. Direct methods include stone riprap revetments, erosion control fabrics and mats, revegetation, burlap sacks, cellular concrete blocks, and bulkheads. Indirect methods include the following: dikes, wire or board fences, gabions, and stone longitudinal dikes.
- Levees are embankments or shaped mounds constructed for flood control or hurricane protection.
- Setback levees and floodwalls are longitudinal structures used to reduce flooding and minimize sedimentation problems associated with fluvial systems. They can be constructed without disturbing the natural channel vegetation, cross section, or bottom slope.
- Check dams are small dams constructed across an influent, intermittent stream, or drainageway to reduce channel erosion by restricting flow velocity. They can serve as emergency or temporary measures in small eroding channels that will be filled or permanently stabilized at a later date, such as in a construction setting.
- Grade control structures are hydraulic barriers (weirs) installed across streams to stabilize the channel, control headcuts and scour holes, and prevent upstream degradation. These structures can be built with a variety of materials, including sheet piling, stone, gabions, or concrete.
- Vegetative cover is used to rehabilitate eroded streambanks. Streambank restoration using vegetation is probably the most commonly used practice, particularly in small tributaries. Vegetative cover, also used in combination with other structural practices, is relatively easy to establish and maintain, is visually attractive, and is the only streambank stabilization method that can repair itself when damaged. Appropriate native plant species should be used.
- Structural, vegetative, or bioengineered practices are used to control instream sediment load. Streambank and channel stabilization practices, including various types of revetments, grade control structures, and flow restrictors, have been effective in controlling sediment production caused by streambank erosion.
- To minimize erosion and remedy sedimentation impacts on nearby water bodies during construction and operation periods, streamside roadway management needs to combine proper design for site-specific conditions with appropriate maintenance practices.

2.5.4.3 Information Resources

- **Lower American River Corridor River Management Plan** (http://www.safca.com/): The plan has a section on aquatic habitat management goals, which includes restoration to improve aquatic habitat impaired by low flows from channel modification of the Lower American River.
- **Bay Institute, Bay Restoration Program** (http://www.bay.org/san_pablo_bay.htm): This Web site describes several bay and wetland restoration projects that are part of an effort to improve the Bay-Delta Ecosystem. The site provides links to information about the Bay, news and publications, and the STRAW (Students and Teachers Restoring A Watershed) Project, which is an organization that plans and implements watershed studies and restoration projects in Marin, Sonoma, and Napa counties.
- **South Sacramento County Streams Project** (http://www.spk.usace.army.mil/): South Sacramento County Streams Project provides flood damage reduction to the urban areas of the Morrison Creek and Beach Stone Lake drainage basins in the southern area of Sacramento, as

well as around the Sacramento Regional Waste Water Treatment Plant. The project will fund stream restoration in southern Sacramento County.

- **Sacramento River Riparian Habitat Program** (http://www.sacramentoriver.ca.gov/): The Sacramento River Riparian Habitat Program is working to ensure that riparian habitat management along the river addresses the dynamics of the riparian ecosystem and the reality of the local agricultural economy.
- **Washington State Department of Transportation, Soil Bioengineering Web site** (http://www.wsdot.wa.gov/eesc/design/roadside/sb.htm): This is a comprehensive Web site, with information on cost, specifications, funding, and case studies.
- **California Forest Stewardship Program, *Bioengineering to Control Streambank Erosion*** (http://ceres.ca.gov/foreststeward/html/bioengineering.html): This fact sheet discusses various bioengineering techniques applicable to California streams.
- **WATERSHEDSS:Water, Soil and Hydro-Environmental Decision Support System** (http://www.water.ncsu.edu/watershedss/): The "Educational Component" section of this Web site contains fact sheets that provide information on a variety of techniques for management practices, including soil bioengineering, structural streambank stabilization, and instream practices.
- **Ohio Department of Natural Resources, *Stream Management Guide Fact Sheets*** (http://www.dnr.state.oh.us/water/pubs/fs_st/streamfs.htm): This is a compilation of fact sheets on technical guidance for streambank and instream practices, general stream management, and stream processes.
- **USDA Natural Resources Conservation Service, *Stream Visual Assessment Protocol*** (http://www.nrcs.usda.gov/technical/ECS/aquatic/svapfnl.pdf): This document outlines methods useful for field conservationists and landowners for the evaluation the ecological condition of a stream.
- **Ann Riley, *Urban Stream Restoration: A Video Tour of Ecological Restoration Techniques*** (http://www.noltemedia.com/nm/urbanstream/): This video, which is 61 minutes long and can be ordered online, is a documentary tour of six urban stream restoration sites. It provides background information on funding, community involvement, and the history and principles of restoration. The demonstration includes examples of stream restoration in very urbanized areas, re-creating stream shapes and meanders, creek daylighting, soil bioengineering, and ecological flood control projects. Ann Riley, a nationally known hydrologist, stream restoration professional, and executive director of the Waterways Restoration Institute in Berkley, California, leads the tour.
- **Natural Resources Conservation Service, *Watershed Technology Electronic Catalog*** (http://www.wcc.nrcs.usda.gov/wtec/wtec.html): This online catalog is a source of technical guidance on a variety of restoration techniques and management practices, to provide direction for watershed managers and restoration practitioners. The site is focused on providing images and conceptual diagrams.

2.5.4.4 Case Studies

Urban Stream Restoration Program. In 2000, a 350-linear-foot section of degraded stream was restored, and failing concrete banks were stabilized using soil-bioengineering techniques (brush layering). Native riparian trees, willows, and cottonwood cuttings were planted, and a trail was graded along one bank. The East Bay Conservation Corps, under the supervision of the Urban Creeks Council, provided the labor. The California Department of Water Resources, Urban Stream Restoration Program, California Coastal Conservancy, and the San Francisco Foundation funded this project (http://www.urbancreeks.org/Current_Projects.html).

Mill Creek Channel Restoration Project. In 2001, Round Valley Indian Tribes, partnering with the FishAmerica Foundation and the National Oceanic and Atmospheric Administration's Restoration Center, initiated a project to restore this stream, located in Mendocino County, California. The purpose of the restoration was to reestablish and improve salmonid habitat within Mill Creek by creating a single, deeper stream channel and a functional riparian corridor. Restoration techniques included the use of riprap wing deflectors, structural streambank stabilization, boulder weirs, and large woody debris. The local community is participating through an Adopt-A-Watershed program, which provides an opportunity for local schools to monitor the success of the project and track changes in the health of the stream (http://yosemite.epa.gov/water/restorat.nsf/California?OpenView).

2.5.4.5 References

Federal Interagency Stream Restoration Working Group (FISRWG). 1998. *Stream Corridor Restoration: Principles, Processes, and Practices*. PB98-158348LUW. Federal Interagency Stream Restoration Working Group, Washington, DC.

Fact Sheet Links:

- ➔ Programs
- ➔ Management Practices
- ➔ Information Resources
- ➔ Case Studies
- ➔ References

2.5.5 Management Measure 5.2A Dams Erosion and Sediment Control

Management Measure

1. Reduce erosion and, to the extent practicable, retain sediment onsite during and after construction.

2. Prior to land disturbance, prepare and implement an approved erosion and sediment control plan or similar administrative document that contains erosion and sediment control provisions.

2.5.5.1 Programs

- The California Water Code entrusts the regulatory Dam Safety Program to the Department of Water Resources. The principal goal of this program is to avoid dam failure and thus prevent loss of life and destruction of property. Dams under State jurisdiction are an essential element of the California infrastructure that provides constant water supply integrity (http://damsafety.water.ca.gov/).
- The Bureau of Reclamation's Dam Safety Program must ensure that dams are operated and maintained in a safe manner through inspections for safety deficiencies, analyses using current technologies and designs, and corrective actions, if needed, based on current engineering practices. In addition, future evaluations should include assessments of benefits forgone with the loss of a dam. For example, a failed dam can no longer provide needed fish and wildlife benefits (http://www.usbr.gov/ssle/dam_safety/).

2.5.5.2 Management Practices

Two broad performance goals constitute this management measure: minimizing erosion and maximizing the retention of sediment onsite. Preparing and implementing an erosion and sediment control plan for dam construction and operation can accomplish these goals. The goals give states and local governments flexibility in specifying practices appropriate for local conditions. Recommended practices to control erosion and sediment control from dams include the following:

- Develop and implement an erosion and sediment control plan (ESC plan) for the dam. These plans describe how a contractor or developer will reduce soil erosion and contain and treat runoff that is carrying eroded sediments. Plans typically include descriptions and locations of soil stabilization practices, perimeter controls, and runoff treatment facilities that will be installed and maintained before and during construction activities. In addition to special area considerations, the full ESC plan review inventory should include topographic and vicinity maps, a site development plan, construction schedule, erosion and sedimentation control plan drawings, detailed drawings and specifications for practices, design calculations, and a vegetation plan. Changes to an ESC plan should be made based on regular inspections that determine whether the ESC practices were appropriate or properly installed or maintained.
- Provide education and training opportunities for designers, developers, and contractors. One of the most important factors determining whether erosion and sediment controls will be properly installed and maintained on a construction site is the knowledge and experience of the contractor.

- Schedule projects so clearing and grading are done during the time of minimum erosion potential. Often a project can be scheduled during the time of year when the erosion potential of the site is relatively low. In many parts of the country, there is a certain period of the year when erosion potential is relatively low and construction scheduling could be very effective (in the Pacific region, for example, the 6-month dry season from May 1 to October 31).
- Plan to use construction phasing. Construction site phasing involves disturbing only small portions of a site at a time to prevent erosion from dormant parts. Elements to consider when phasing construction activities include managing runoff separately in each phase, determining whether water and sewer connections and extensions can be accommodated, determining the fate of already completed downhill phases, and providing separate construction and residential accesses to prevent conflicts between residents living in completed stages of the site and construction equipment working on later stages.

2.5.5.3 Information Resources

- **California Storm Water Quality Association, *Construction Handbook***
(http://www.cabmphandbooks.org/Construction.asp): The *Construction Handbook* provides general guidance for selecting and implementing management practices that will eliminate or reduce the discharge of pollutants from construction sites to waters of the State. The practices for erosion and sediment control are included in Section 3 of the handbook.
- **California Coastal Commission, Beach Erosion and Response Document**
The *Beach Erosion and Response Guidance Document*, or BEAR, is now available by request from the California Coastal Commission. This document provides general information about types of shorelines and seawalls, as well as guidance for analyzing shoreline activities. To receive a copy, call the Technical Services Unit in the Headquarters Office (Telephone: 415-904-5240).
- **Resources Agency of California, Draft Policy on Coastal Erosion Planning and Response and Background Material**
The draft policy on coastal erosion planning and response focuses on responding to erosion at the coastline with actions that will cause the least environmental damage, while protecting existing coastal infrastructure. The draft policy outlines a tiered approach that proposes the following broad policy goals: (1) increasing sand supply to the coast; (2) avoiding the construction of new structures in hazardous areas; (3) if structures are threatened, considering the feasibility of re-locating them; (4) using beach nourishment (placing sand on or near eroding beaches) as the first priority for stabilizing beaches, if feasible; (5) using hard protective structures (seawalls, revetments, breakwaters, etc) only if other less environmentally damaging alternatives are deemed infeasible. The draft policy and background material can be found at http://resources.ca.gov/ocean/coastal_erosion_draft.html.
- **Russellville Water Intake Environmental Assessment**
(http://www.tva.gov/environment/reports/russell/ea_text.htm): This environmental assessment was prepared for the addition of a special reservoir drawdown during construction of intake at mile 32.4R on Cedar Creek Reservoir, Franklin County, Alabama.
- **Wyoming Department of Environmental Quality, *Hydrologic Modifications Best Management Practices*** (http://deq.state.wy.us/wqd/watershed/Downloads/NPS Program/92251.pdf): This manual provides information on the management practices recommended by the Wyoming Department of Environmental Quality for protecting streams and riparian areas from hydrologic modifications.

Fact Sheet Links:

- ➔ Programs
- ➔ Management Practices
- ➔ Information Resources
- ➔ Case Studies
- ➔ References

2.5.6 Management Measure 5.2B Dams Chemical and Pollutant Control

Management Measure

1. Limit application, generation, and migration of toxic substances.

2. Ensure the proper storage and disposal of toxic materials.

3. Apply nutrients at rates necessary to establish and maintain vegetation without causing significant nutrient runoff to surface waters.

2.5.6.1 Programs

- The Bureau of Reclamation's Dam Safety Program must ensure that dams are operated and maintained in a safe manner through inspections for safety deficiencies, analyses using current technologies and designs, and corrective actions, if needed, based on current engineering practices. In addition, future evaluations should include assessments of benefits forgone with the loss of a dam. For example, a failed dam can no longer provide needed fish and wildlife benefits (http://www.usbr.gov/ssle/dam_safety/).
- The California Resources Agency, Department of Water Resources, Division of Safety of Dams conducts investigations of selected dams, which include a comprehensive review of all pertinent material contained in the Division's files, a visual project inspection, technical studies when necessary, and preparation of a comprehensive report (http://damsafety.water.ca.gov/about.htm).

2.5.6.2 Management Practices

The purpose of this management measure is to prevent downstream contamination from pollutants associated with dam construction and maintenance activities. Recommended practices used to control chemical pollution from dam construction sites include the following:

- Develop and implement a spill prevention program. Spill procedure information should be posted, and persons trained in spill handling should be onsite or on call at all times. Materials for cleaning up spills should be kept onsite and easily available. Spills should be cleaned up immediately and the contaminated material properly disposed of.
- Control pollutant runoff from equipment. During both construction and maintenance activities at dams, equipment and machinery can be a potential source of pollution to the surface and ground waters.
- Establish fuel and maintenance staging areas. Proper maintenance of equipment and installation of proper stream crossings further reduces pollution of water by these sources. Vehicles need to be inspected for leaks. To prevent runoff, fuel and maintain vehicles onsite only in a bermed area or over a drip pan.
- Store, cover, and isolate construction materials, refuse, garbage, sewage, debris, oil and other petroleum products, mineral salts, industrial chemicals, and topsoil to prevent runoff of pollutants and contamination of ground water.

- Mix, transport, load, and apply pesticides correctly and dispose of their containers properly to prevent potential NPS pollution. Fertilizers should be handled and applied properly.

2.5.6.3 Information Resources

- **USEPA, *Spill Prevention Planning*** (http://www.epa.gov/npdes/pubs/spillprv.pdf): This fact sheet outlines key programmatic components to establishing spill prevention plans.

Fact Sheet Links:

- ➔ Programs
- ➔ Management Practices
- ➔ Information Resources
- ➔ Case Study
- ➔ References

2.5.7 Management Measure 5.2C Dams Protection of Surface Water Quality and Instream and Riparian Habitat

Management Measure

Develop and implement a program to manage the operation and maintenance of dams that includes an assessment of

1. Surface water quality and instream and riparian habitat and potential for improvement, and

2. Significant NPS pollution problems that result from excessive surface water withdrawals.

2.5.7.1 Programs

- The Department of Fish and Game is responsible for conserving, protecting, and managing California's fish, wildlife, and native plant resources. To meet this responsibility, the law requires any person, State, or local government agency, or public utility proposing a project that may impact a river, stream, or lake to notify the Department before beginning the project. If the Department determines that the project may adversely affect existing fish and wildlife resources, a Lake or Streambed Alteration Agreement is required (http://www.dfg.ca.gov/1600/).
- California Department of Water Resources Fish Passage Improvement Program staff meet with local, State, and federal agencies and stakeholder partners to plan and implement projects to remove barriers that impede migration and spawning of anadromous fish species. This program's Web site has a link to a table of dams removed in California (http://www.watershedrestoration.water.ca.gov/fishpassage/impediments/).
- The goal of the American Rivers campaign, Rivers Unplugged, is to restore rivers critical to fish and wildlife by removing dams that no longer make sense. The primary focus of the Rivers Unplugged California Field Office is to provide technical assistance and other guidance to individual dam removal efforts (http://www.americanrivers.org/site/PageServer?pagename=AMR_content_98c5).

2.5.7.2 Management Practices

The purpose of this management measure is to protect the quality of surface waters and aquatic habitat in reservoirs and in the downstream portions of rivers and streams that are influenced by the quality of water contained in the releases (tailwaters) from reservoir impoundments. Impacts from the operation of dams on surface water quality and aquatic and riparian habitat should be assessed and the potential for improvement evaluated. In addition, potential upstream and downstream impacts on surface water quality and aquatic and riparian habitat that would be caused by the implementation of practices should also be considered in the assessment. The overall program approach is to evaluate a set of practices that can be applied individually or in combination to protect and improve surface water quality and aquatic habitat in reservoirs, as well as in areas downstream of dams. After this evaluation, the most cost-effective operations should be implemented to protect and improve, where economically feasible, surface water quality and aquatic and riparian habitat.

Recommended practices for aeration of reservoir waters and releases include the following:

- Pumping and injection systems. Water pumps have been used to move surface water containing higher concentrations of dissolved oxygen downward to mix with deeper waters as the two strata are entering the turbine. Oxygen injection systems use pure oxygen to increase levels of dissolved oxygen in reservoirs.
- Turbine venting. This is the practice of injecting air into water as it passes through a turbine.

Recommended practices to improve oxygen levels in tailwaters include the following:

- Gated conduits. These are hydraulic structures that divert the flow of water under the dam. They are designed to create turbulent mixing to enhance the rest of the oxygen transfer.
- Spillways and overflow weirs. These are important structures in improving dissolved oxygen levels.
- Spillway modifications. Spillways can be modified by cutting a notch to prevent water from plunging directly into the stilling basin
- Reregulation weirs. This type of weir has been constructed from stone, wood, and aggregate. In addition to increasing the levels of dissolved oxygen in the tailwaters, reregulation weirs result in a more constant rate of flow farther downstream during periods when turbines are not in operation.
- Labyrinth weirs. This type of weir has extended crest length and is usually W-shaped. These weirs spread the flow out to prevent dangerous undertows in the plunge pool.
- Selective withdrawal. Multilevel intake devices in storage reservoirs allow selective withdrawal of water based on temperature and dissolved oxygen levels.
- Turbine operation. Implementation of changes in the turbine start-up procedures can also enlarge the zone of withdrawal to include more of the epilimnetic waters in the downstream releases.

Recommended watershed protection practices include the following:

- Land use planning. Planning establishes guidelines for permissible uses of land within a watershed and serves as a guide for reservoir management programs addressing NPS pollution.
- NPS screening and identification. The analysis and interpretation of stereoscopic color infrared aerial photographs can be used to find and map specific areas of concern where a high probability of NPS pollution exists from septic tank systems, animal wastes, soil erosion, and other similar types of NPS pollution.
- Soil erosion control. Soil erosion has been determined to be the major source of suspended solids, nutrients, organic wastes, pesticides, and sediment that, when combined, form the most problematic form of NPS pollution.
- Ground water protection. Proper protection and management of ground water resources primarily depends on the effective control of NPS pollution, particularly in ground water recharge areas.
- Mine reclamation. Old mines need to be located and reclaimed to reduce the NPS pollutants emanating from them. Revegetation is a cost-effective method of reclaiming denuded strip-mined lands.
- Animal waste control. A major contributor to reservoir pollution in some watersheds is wastes from confined animal facilities.

- Failing septic system control. Septic systems should be sited, designed, and installed so that impacts on water bodies will be reduced to the extent practicable.

Practices to restore or maintain aquatic and riparian habitat include the following:

- Flow augmentation. A flushing flow is a high-magnitude, short-duration release for the purpose of maintaining channel capacity and the quality of instream habitat by scouring the accumulation of fine-grained sediments from the streambed.
- Riparian improvements. These include reducing sediment loading in the watershed, improving riparian vegetation, eliminating barriers to fish migration, and providing greater instream and riparian habitat diversity

Practices to maintain fish passage include the following:

- Behavioral barriers. Such barriers use fish responses to external stimuli to keep fish away from the intakes or to attract them to a bypass.
- Physical barriers. These include barrier nets and stationary screens to prevent the entry of fish and other aquatic organisms into the intakes at a generating facility.
- Collection systems. These are used to capture fish by screening and/or netting, followed by transport by truck or barge to a downstream location.
- Fish diversion systems. These lead or force fish to bypasses that transport them to the natural water body below the dam.
- Spill and water budgets. Spill budgets provide alternative methods for fish passage that are less dangerous than passage through turbines. The water budget is the mechanism for increasing flows through dams during the out-migration of anadromous fish species.
- Fish ladders. These are one type of structure that can be provided to enable the safe upstream and downstream passage of mature fish.
- Transfer of fish runs. Transfer involves inducing anadromous fish species to use different spawning grounds in the vicinity of the impoundment.
- Constructed spawning beds. When the adverse effects of a dam on the aquatic habitat of an anadromous fish species are severe, one option may be to construct suitable replacement spawning beds.

2.5.7.3 Information Resources

- **California Department of Water Resources Fish Passage Improvement Program, *Bibliography*** (http://www.watershedrestoration.water.ca.gov/fishpassage/references/): This Web site provides several references on fish species biology, dam removal, geomorphology, fish passage structures, riparian and instream restoration, road crossings, and riparian vegetation.
- **California Department of Fish and Game (DFG), Lake or Streambed Alterations Agreements** (http://www.dfg.ca.gov/1600/brochure.pdf): This brochure provides information on the DFG lake or streambed alterations notification and agreement program.
- **California Salmonid Stream Habitat Restoration Manual** (http://www.dfg.ca.gov/1600/brochure.pdf): This manual formally explains and describes the DFG ground level approach to restoration of fishery resources, and standardizes the DFG's descriptive terminology and technical methods. Principal emphasis is on salmon, steelhead, and

trout; therefore, this manual is principally intended to be used to assist in restoration efforts for those species in California.

2.5.7.4 Case Study

Battle Creek Restoration Project. A plan to restore rare Chinook salmon and steelhead by removing five dams, constructing fish ladders, and improving stream flow in 42 miles of Northern California's Battle Creek was announced in 1999. Spring-fed Battle Creek, a major Sacramento River tributary, is the first stream in California to which several species of salmon will be able to return and find their original spawning grounds.

The Battle Creek restoration proposal includes increasing the minimum instream flows from the present amount of 3 to 5 cubic feet per second (cfs) year round to approximately 35-88 cfs adjusted seasonally; decommissioning five diversion dams (Wildcat, Coleman, South, Lower Ripley Creek, and Soap Creek) and transferring their associated water rights to instream uses; screening and enlarging ladders at three diversion dams (Inskip, Eagle Canyon, and North Battle Creek Feeder); and constructing new infrastructure to eliminate mixing of North and South Fork waters. Screening prevents fish from getting pulverized in the dams' turbines.

This restoration is being done under the CALFED Bay-Delta Program, which was formed in 1994. It is a joint federal and State agreement to improve California's water and ecosystem quality as well as the water supply reliability and the vulnerability of Delta functions in and around San Francisco, Sacramento, and Stockton, CA (http://www.usbr.gov/mp/battlecreek/).

Fact Sheet Links:
- Programs
- Management Practices
- Information Resources
- Case Study
- References

2.5.8 Management Measure 5.3A Streambank and Shoreline Erosion Eroding Streambanks and Shorelines

Management Measure

1. Where streambank or shoreline erosion is a NPS problem, streambanks and shorelines should be stabilized. The use of vegetative stabilization methods is strongly preferred over the use of structural stabilization methods, if appropriate considering the climate, severity of wave and wind erosion, offshore bathymetry, and the potential adverse impacts on other streambanks, shorelines, and offshore areas.

2. Protect streambank and shoreline features with the potential to reduce NPS pollution.

3. Protect streambanks and shorelines from erosion due to uses of either the shorelands or adjacent surface waters.

2.5.8.1 Programs

- The California Coastal Commission's primary mission is to plan for and regulate land and water uses in the coastal zone consistent with the policies of the Coastal Act. Programs include permitting, planning, enforcement, and resource protection (http://www.coastal.ca.gov/).
- The CALFED Bay-Delta Program's mission is to develop and implement a long-term comprehensive plan that will restore ecological health and improve water management for beneficial uses of the Bay-Delta System (http://www.calwater.ca.gov/).
- The California Department of Fish and Game's mission is to manage California's diverse fish, wildlife, and plant resources, and the habitats upon which they depend, for their ecological values and for their use and enjoyment by the public (http://www.dfg.ca.gov/).

2.5.8.2 Management Practices

- Use bioengineering and other vegetative techniques to restore damaged habitat along shorelines and streambanks wherever conditions allow.
    - Live staking involves the insertion and tamping of live, rootable vegetative cuttings into the ground.
    - Live fascines are long bundles of branch cuttings bound together into sausage-like structures. When cut from appropriate species and properly installed, they will root and immediately begin to stabilize slopes.
    - Brush layering consists of placing live branch cuttings in small benches excavated into the slope. The portions of the brush that protrude from the slope face assist in retarding runoff and reducing surface erosion.
    - Brush mattressing involves digging a slight depression on the bank and creating a mat or mattress from woven wire or single strands of wire and live, freshly cut branches from sprouting trees or shrubs.

  - Branch packing consists of alternating layers of live branch cuttings and compacted backfill to repair small localized slumps and holes in slopes.
  - Joint planting involves tamping live cuttings of rootable plant material into soil between the joints or open spaces in rocks that have previously been placed on a slope.
  - Live cribwalls consist of a hollow, box-like interlocking arrangement of untreated log or timber members. The structure is filled with suitable backfill material and layers of live branch cuttings, which root inside the crib structure and extend into the slope.

- Use properly designed and constructed engineering practices for shore erosion control in areas where practices involving marsh creation and soil bioengineering are ineffective.
  - Bulkheads are primarily soil-retaining structures designed also to resist wave attack.
  - Seawalls are principally structures designed to resist wave attack, but they also may retain some soil. Both bulkheads and seawalls may be built of many materials, including steel, timber, or aluminum sheet pile, gabions, or rubble-mound structures.
  - Revetment design contains several layers of randomly shaped and randomly placed stones, protected with several layers of selected armor units or quarry stone. The armor units in the cover layer should be placed in an orderly manner to obtain good wedging and interlocking between individual stones. The cover layer may also be constructed of specially shaped concrete units.
  - Gabions (stone-filled wire baskets) or interlocking blocks of precast concrete are used in the construction of revetments. In addition to the surface layer of armor stone, gabions, or rigid blocks, successful revetment designs also include an underlying layer composed of either geotextile filter fabric and gravel or a crushed stone filter and bedding layer.
  - Groins are structures that are built perpendicular to the shore and extend into the water. Groins are generally constructed in series, referred to as a groin field, along the entire length of shore to be protected. Groins trap sand in littoral drift and halt its longshore movement along beaches. The sand beach trapped by each groin acts as a protective barrier that waves can attack and erode without damaging previously unprotected upland areas.
  - Breakwaters are wave energy barriers designed to protect the land or nearshore area behind them from the direct assault of waves.

- In areas where existing protection methods are being flanked or are failing, implement properly designed and constructed shore erosion control methods.
  - Toe protection usually takes the form of a stone apron installed at the base of the vertical structure to reduce wave reflection and scour of bottom sediments during storms.
  - Return walls should be provided at either end of a vertical protective structure and should extend landward for a horizontal distance consistent with the local erosion rate and the design life of the structure.
  - Maintenance of structures is necessary to repair the damage from storms and winter ice and to address the effects of flanking and offshore profile deepening.

- Plan and design all streambank, shoreline, and navigation structures so that they do not transfer erosion energy or otherwise cause visible loss of surrounding streambanks or shorelines. Many streambank or shoreline protection projects result in a transfer of energy from one area to another, which causes increased erosion in the adjacent area. Property owners should consider the possible effects of erosion control measures on other properties located along the shore.

- No-wake zones should be established and enforced. No-wake zones should be given preference over posted speed limits in shallow coastal waters and inland lakes and streams for reducing the erosion potential of boat wakes on streambanks and shorelines.
- Setbacks should be established to minimize disturbance of land adjacent to streambank and shorelines to reduce other impacts. Setbacks most often take the form of restrictions on the siting and construction of new standing structures along the shoreline.
- Upland drainage from development should be directed away from bluffs and banks so as to avoid accelerating slope erosion.

2.5.8.3 Information Resources

- **Sacramento River Riparian Habitat Program** (http://www.sacramentoriver.ca.gov/): The Sacramento River Riparian Habitat Program is working to ensure that riparian habitat management along the river addresses the dynamics of the riparian ecosystem and the reality of the local agricultural economy.
- **California Forest Stewardship Program, *Bioengineering to Control Stream Bank Erosion*** (http://ceres.ca.gov/foreststeward/html/bioengineering.html): This fact sheet includes information on using bioengineering techniques to control streambank erosion.
- **Bioengineering for Hillslope, Streambank, and Lakeshore Erosion Control** (http://www.ianr.unl.edu/pubs/Soil/g1307.htm): This NebGuide (part of a series published by the Cooperative Extension of the University of Nebraska) describes bioengineering techniques for hill slope, streambank, and lakeshore erosion control. Tips for a successful bioengineering installation and demonstration project are described.
- **California Environmental Resources Evaluation System (CERES)** (http://ceres.ca.gov/): CERES is an information system developed by the California Resources Agency to facilitate access to a variety of electronic data describing California's rich and diverse environments. The goal of CERES is to improve environmental analysis and planning by integrating natural and cultural resource information from multiple contributors and by making it available and useful to a wide variety of users.

2.5.8.4 Case Study

Beaches Starved of Sand Because of Dams. Four hundred miles of California's fabulous beaches are starving for sand, but surfers and other beach lovers have the muscle to bring them back. Beaches are disappearing mostly because of dams. Seventy to 90 percent of the sand on California beaches comes from rivers, and millions of tons of sand-laden sediments are now trapped behind the 1,400 dams that were built in California between l850 and l970. Twenty percent of the sand on California's beaches comes from the natural erosion of bluffs (http://www.ecoiq.com/magazine/opinion/opinion61.html).

2.5.8.5 References

Federal Interagency Stream Restoration Working Group (FISRWG). 1998. *Stream Corridor Restoration: Principles, Processes, and Practices*. PB98-158348LUW. Federal Interagency Stream Restoration Working Group, Washington, DC.

Fact Sheet Links:

- ➔ Programs
- ➔ Management Practices
- ➔ Information Resources
- ➔ Case Study
- ➔ References

2.5.9 Management Measure 5.4A Education/Outreach Educational Programs

Management Measure

Implement educational programs to provide greater understanding of watersheds, to raise awareness and increase the use of applicable hydromodification management measures and practices where needed to control and prevent adverse impacts on surface and ground waters, and to promote projects that retain or reestablish natural hydrologic functions (e.g., channel restoration projects). Public education, outreach, and training programs should involve applicable user groups and the community.

2.5.9.1 Programs

- The Clean Water Team Citizen Monitoring Program is part of the SWRCB's NPS Pollution Control Program. Regional coordinators provide technical assistance, training, data management consultation, outreach, and education to citizen monitoring organizations. The program provides an opportunity for the public to participate in stewardship efforts and learn about the issues facing their local watersheds (http://www.swrcb.ca.gov/nps/volunteer.html).

2.5.9.2 Management Practices

- Focus on the development and implementation of pollution prevention and education programs for agency staffs and the public.
- Promote assistance tools that emphasize restoration and low impact development.
- Promote projects that reduce NPS pollutants, retain or reestablish natural hydrologic regimes, and/or prevent or remedy adverse effects of hydromodification activities.

2.5.9.3 Information Resources

- **Adopt-A-Watershed** (http://www.adopt-a-watershed.org/): The Adopt-A-Watershed Program's Web site provides school curricula, as well as information on its consulting services and training programs, and links to local Adopt-A-Watershed groups.
- **Adopt-A-Stream Foundation** (http://www.streamkeeper.org/): The Adopt-A-Stream Foundation, based in Washington, travels to communities around the country to provide education and outreach for students, professionals, and government officials.
- **USEPA, *Volunteer Stream Monitoring: A Methods Manual*** (http://www.epa.gov/volunteer/stream/): This guide discusses volunteer stream monitoring in terms of its role in state monitoring programs, and provides information on how to organize, implement, and maintain volunteer programs. Instream physical, chemical, and biological assessments are covered, as well as land use or watershed assessments.
- **Arroyo Seco Foundation** (http://www.arroyoseco.org): The Arroyo Seco Foundation works to protect and restore the Arroyo Seco watershed, which is part of the Los Angeles River watershed. The foundation also promotes environmental awareness and education.

- ***Riverwatch River and Watershed Conservation Directory*** (http://www.riverwatch.org/library/libnetdirsearch.cfm): The River Network and the Rivers, Trails and Conservation Assistance Program of the National Park Service maintain this comprehensive directory, which lists over 3,600 river and watershed conservation groups, as well as local government agencies. The directory is searchable by city, state, and organization name.
- **The Council of State Governments, *Getting in Step: A Guide to Effective Outreach in Your Watershed*** (http://www.epa.gov/watertrain/gettinginstep/): This Web site is an online training module that provides guidance on the development of an outreach program. Downloadable worksheets are provided for use in the planning process.
- **California Regional Environmental Education Community** (http://www.creec.org/): This online network is a source of environmental education resources, with links to curriculum and a statewide searchable research directory.
- ***University of Wisconsin* Cooperative State Research, Education, and Extension Service, Best Education Practices Project** (http://wateroutreach.uwex.edu/beps/index.cfm): The University of Wisconsin Cooperative State Research, Education, and Extension Service has initiated the Water Outreach Education project, also known as the Best Education Practices project, to help natural resource management and outreach professionals to choose appropriate education techniques and resources for their water management programs. The Best Education Practices project will work in collaboration with the federal agency clean and safe water partnership and other networks to develop and promote best education practices for water education and to improve access to education resources and strategies. Project activities reflect advice provided by federal agency clean and safe water partners and a national network of water education organizations created and supported by the work of several national organizations over the last decade. Projects have included a 2002 Study of Provider Needs, Model Education Technique, a literature search, Best Education Practices Pilot Web site, and other reference materials related to water outreach education.

2.5.9.4 Case Study

Urban Creeks Council Environmental Education Program. In conjunction with hands-on projects, the Urban Creeks Council (UCC) of California works with schools and community groups to try to build a sense of stewardship for the creeks. UCC works with elementary school teachers, taking students on field trips to local creeks to learn about creek ecology, and with high school teachers, teaching students to understand how streams and rivers function, how to survey and graph creek cross sections and profiles, to conduct pebble counts, and to identify native riparian trees, shrubs, and other plants (http://www.urbancreeks.org/Current_Programs.html).

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